THE GEOMORPHOLOGY OF THE HUNTER RIVER DISTRICT, N.S.W.

By C. A. Sussmilch.

(Plate x; three Text-figures.)

[Read 29th May, 1940.]

It is proposed in this paper to describe the geomorphology of that part of eastern New South Wales which is drained by the Hunter River and its tributaries; this river is one of the larger streams flowing from the eastern side of the Main Divide to the coast, and the position of its watershed is indicated on the map (Pl. x). This area, which is one of the most important industrial and pastoral regions of the State, is relatively low, most of it being under 2000 feet in altitude, although limited areas along some of its margins considerably exceed this amount; the regions to the north and south of it are, however, much higher. To the north lies the New England Tableland varying from 3000 to upwards of 5000 feet in altitude, while to the south lies the Central or Blue Mountain Tableland ranging from 3000 to 4000 feet in altitude.

No previous attempt has been made to give a detailed description of the physiography of this region as a whole, but various writers have made reference to some of the physiographical features of certain parts of it, usually in connection with a description of the geology. The first important reference was that by E. C. Andrews (1903), who gave a brief description of some of the features of the Hunter River Valley; in a later paper (1910) he suggested that the scarps along the western and southern sides of the Barrington Tableland are fault-scarps. In 1912 the same writer published a description of a relief model of New England which included the northern portion of the Hunter River Valley; and later he (1914) expressed the opinion that the Main Divide in the Hunter River area had had a tectonic origin, without, however, quoting any detailed evidence in support of this view. The present writer (1914) put forward a similar view.

T. Griffith Taylor (1906), dealing with the western part of the Hunter River drainage area, ascribed its relatively low elevation, as compared with the higher elevation of the tablelands immediately to the north and south of it, to the relatively easy and rapid cutting down of the weak coal measures by the Goulburn River and its tributaries; he was evidently of the opinion that the whole of the surface of this region was occupied by the Upper Coal Measures of Permian age. He stated that "it is possible that the New England massif originally extended towards the south and joined the Blue Mountains massif with but little lowering of the 3000 ft. contour. There is little doubt at any rate as to the action of the Hunter and its tributaries in materially reducing the level of this region and thus leading to the diversities in temperature and rainfall." As will be shown later, his views are not supported by the evidence. In a later paper Taylor (1911) again referred to this area and suggested that all that part of the Hunter River system west of Singleton at one time flowed westward and formed a part of the Macquarie River system.

The present writer (1920) gave a brief description of some of the physiographical features of the Hunter River Valley. W. R. Browne (1924) described some of the physiographical features of the Upper Hunter River district, and G. D. Osborne (1929) described the physiography of a relatively narrow belt of country extending from Scone eastward to Raymond Terrace. J. A. Dulhunty (1938) made reference to some of the physiographical features of the Wollar District.

SUBDIVISIONS.

For purposes of description it will be convenient to divide the area under consideration into the following divisions:

A.	The Lower Hunter Tableland	General altitude 1400 to 1500 feet
B.	The Barrington Tableland	General altitude 4000 to 5000 feet
C.	The Upper Hunter Tableland	General altitude 2200 to 3300 feet
D.	The Goulburn River Tableland	General altitude 1450 to 2200 feet
E.	The Blue Mountain Tableland	General altitude 2000 to 4000 feet

This subdivision is based primarily on differences in altitude, and to a less extent on differences in geological structure; geologically the region falls naturally into two divisions. In the north-eastern part, which comprises the whole of the Barrington and Upper Hunter Tablelands together with most of that part of the Lower Hunter Tableland lying to the north of the Hunter River, the underlying geological formations consist dominantly of Devonian and Carboniferous strata with a quite subordinate extent of Permian strata; all of these formations are strongly folded, and upon their truncated edges in many places lie horizontal flows of Tertiary basalt, particularly in the northern section. Throughout the remaining portion of the Hunter River drainage area the geological formations are, for the most part, quite unfolded, and consist of a thick series of Mesozoic strata, resting, for the most part conformably, upon an underlying thick series of Permian strata, the latter extending down to and below sea-level; such limited folding of the Permian strata as occurs in this section soon flattens out and disappears southward and westward. Resting in places upon the Mesozoic strata, with a definite but not very pronounced unconformity, are a series of Tertiary basalt flows; these are particularly well developed in the north-western part of the area.

The physiographic features of each of the subdivisions listed above will now be described in turn.

A. THE LOWER HUNTER TABLELAND.

This portion of the drainage area of the Hunter River extends from the seacoast westward to Muswellbrook, a distance of about 60 miles, where it joins the Goulburn River Tableland. Northward it extends to the Barrington and Upper Hunter Tablelands, while southward it extends to and continues beyond the southern boundary of the Hunter River watershed. This tableland has been very completely dissected since its uplift, and but little of the original surface now remains; the general altitude of its surface, as indicated by the heights of the various trigonometrical stations which lie upon it, is about 1400–1500 feet; in the southern area the following trigonometrical stations occur; Heaton (1582 feet), Myall (1550 feet), Quarrybylong (1411 feet), Milfield (1450 feet), Barraba (1694 feet), and Mount Warrawolong (2020 feet); near its western margin are Ogilvie (1518 feet), and Arthur (1567 feet), both near Muswellbrook; and in the northern section Mount Tangorin (1532 feet), George (1466 feet), and Richardson (1536 feet). The close correspondence in altitude of all of these high points (with the exception of Mount Warrawolong) over such a wide area, nearly 3000 square miles, is strong presumptive evidence that the original altitude of the tableland was approximately 1400–1500 feet. Some of these appear to project slightly, but not notably above the general tableland level. Mount Warrawolong is an isolated basalt-capped peak, and its greater altitude is due to the thickness of the basalt capping. T. W. E. David (1907) stated that basalt (dolerite) extends from the summit down to an altitude of 1320 feet. There is, however, one section of this tableland—the Broken Back Range lying just to the west of the town of Cessnock—definitely above the general 1400–1500-foot level; this is not an isolated peak like Mount Warrawolong, but is a narrow tableland extending from Wollombi northward nearly to Singleton, and increasing in altitude northward, reaching at its northern end an elevation of 1925 feet. Like the surrounding lower tableland, it is capped with a thick series of Triassic sandstones which are, however, no thicker here than in the surrounding lower areas, and near Wollombi these massive sandstones are seen to be definitely tilted downward towards the lower level lying to the west. The Broken Back Range therefore appears to be a part of the tableland which at the time of uplift was warped upwards above its surroundings. It is interesting to note that this upwarped area corresponds closely in position and trend to the Lochinvar Anticline in which the Permian strata were notably elevated above their surroundings when undergoing folding towards the close of the Permian Period.

The Hunter River Valley traverses the Lower Hunter Tableland from west to east, and divides it into two sections, which have very different geological structures; in the southern section the tableland is capped by a series of massive sandstones, grits and conglomerates ranging up to 1000 feet in thickness, and these rest upon a thick series of Permian strata consisting mainly of interbedded shales and sandstones. The Triassic strata are for the most part quite unfolded and are nearly horizontal, with but a slight dip to the south; the Permian strata in the northern part of this section adjacent to the Hunter River are definitely folded, but southward the folds soon flatten out, and the strata become nearly horizontal. In the northern section, on the other hand, the strata consist dominantly of highly-folded Devonian and Carboniferous strata with small areas of folded Permian strata along the southern margin. In both northern and southern sections some small patches of Tertiary basalt occur on the tableland surface, apparently residuals of one-time extensive lava flows.

The present valley of the Lower Hunter River is located approximately along the line of junction between the highly-folded Carboniferous and Devonian strata of the northern area and the practically unfolded Permian and Triassic strata of the southern area, and here a very wide mature valley has been developed. The Permian strata which occur at base-level along this part of the Hunter River form a very weak structure, and once the overlying resistant Triassic sandstones had been cut through, rapid widening of the valley took place, particularly along its southern side, not only along the course of the Hunter River itself, but also along the courses of all of its southern tributaries, giving wide, nearly flat-floored valleys, along whose sides are high, almost vertical escarpments of the Triassic sandstones. Southwards these flat-floored valleys head into narrow gorges cut in the Triassic sandstones.

In the northern section, in the highly folded formations, the rivers, such as the Paterson and Williams, follow the general strike of the strata and have developed relatively narrow sub-parallel valleys separated from one another by sharp, narrow hog-back ridges.

The fact that the 1400–1500-foot level of the original tableland extended uniformly through both the folded and unfolded strata of the whole of the Lower Hunter Tableland area suggests that this surface, before it was uplifted, was a peneplain.

B. THE BARRINGTON TABLELAND.

This tableland, which lies to the north of the eastern part of the Lower Hunter Tableland just described, has an altitude varying from 4000 to 5000 feet; this is the highest part of the Hunter River watershed; it is really a part of the New England Tableland which projects southward into the Hunter River Valley. It is highest along its southern margin; there known as the Barrington Tops, where its general altitude is 4900 feet, with some few points, such as Carey's Peak, slightly exceeding 5000 feet in altitude. The northern portion, known locally as the Hunter Tops and Thunderbolt Tops, is not so high, ranging from 4000 to 4500 feet in height. Only the southern and western margins of the Barrington Tableland are drained by the Hunter River and its tributaries, the major part of it falling within the watershed of the Manning River. It should be noted that this high tableland, one of the highest regions in New South Wales, does not lie on the Main Divide, but is located to the east of it and lies entirely within the watersheds of eastern river systems.

The Barrington Tableland is very deeply dissected, particularly so along its eastern margin, but in the south-western section there remains a considerable portion, some 60 square miles or more in area, which is still practically unaffected by the activities of the present cycle of erosion and which displays a remnant of the Tertiary land surface as it existed there before the tableland was uplifted. The general level surface of the tableland of this area is modified by the presence on it of a series of broad mature valleys sunk below the tableland and from 400 to 600 feet deep; such mature valleys are particularly well developed about the head-waters of the Barrington River, Upper Manning (Gummi) River, Polblue Creek, and Moonan Brook, the two last-named streams being tributaries of the Upper Hunter River. The maturity of the topography of the country about the head-waters of these streams is in marked contrast with what is found a few miles downstream, where these rivers suddenly plunge into profound and almost impassable gorges 3000 feet or more in depth.

The Barrington Tableland consists of a thick series of highly folded strata of Devonian and Carboniferous age, associated with which are some extensive granite intrusions; resting unconformably upon the truncated edges of these formations there is a series of horizontal basaltic lava flows of Tertiary age. This volcanic series caps the whole of the tableland, but in the upland valleys just described, the lava flows have been cut through and the much older intrusive granites exposed. These granite outcrops have not been surveyed in detail, but in an unpublished map prepared by the surveyors of the Lands Department their boundaries are shown approximately and the figures given indicate the altitude of the contact of basalts and the granites to be a fairly uniform one varying from 4200 to 4500 feet. These conditions suggest that throughout this area of about 60 square miles the surface of the older rocks upon which the basalts were deposited was a peneplain with no great relief, and that the volcanic series as a whole do not much exceed 700 feet in thickness. Along the western margin of the Barrington Tableland, however, different conditions are found, and from this region Dr. G. D. Osborne kindly supplied to the writer the following information regarding the altitude of the base of the volcanic series as well as its thickness:

Locality.	Altitude of Base of Volcanic Series.	Thickness of Volcanic Series.
Mt. Royal	2800 – 2900 feet	964 feet
Mt. Cockcrow	2900 – 3000 feet	1550 feet
Mt. Woolomin	2800 – 3300 feet	1670 feet +
Stewart's Brook	3000 feet	
Moonan Brook	3100 feet	
Road, Moonan to Wharton's Mill	3300 feet	700 feet

All these observations were made on steep hill-sides where, owing to the tendency of basalt boulders to drift down the slope, it is difficult to locate accurately the true base of the volcanic series, so that the correspondences in the figures from these six localities may be even closer than the figures actually indicate, and it appears to be reasonable therefore to accept a general average of about 3000 feet as the altitude here of the base of the volcanic series. These six localities lie along an approximately north-south line some twenty-four miles in length and at each of them the volcanic series rests upon the truncated edges of folded Devonian and Carboniferous strata. At Murrurundi, some 30 miles westward of the northern end of this line, the writer has determined the altitude of the base of the volcanic series to be also at 3000 feet, and here, too, they rest upon the truncated ends of folded Carboniferous strata. These facts suggest that along the whole of the western margin of the Barrington Tableland, and thence along the southern margin of the New England Tableland to Murrurundi, the Tertiary volcanic series rests upon a peneplained surface of no great relief, and that this feature, together with the base of the volcanic series, now stands at an altitude of approximately 3000 feet. This is some 1200 to 1500 feet lower than the altitude of the suggested possible peneplain surface in the granite region immediately to the east; such a difference in altitude can be explained in either of two ways: (*a*) that a post-basalt fault or a monoclinal fold with an approximate north-south trend separates the two areas, or (*b*) that the granite outcrops in the eastern area are not parts of a peneplained surface, but are the tops of one or more granite residuals rising some 1200 to 1500 feet above a peneplained surface at their bases, and subsequently submerged under the Tertiary volcanic series, which in that case would need to be upwards of 1900 feet in thickness. The absence of any surface features, such as a fault scarp between the two regions; the great thickness of the volcanic series at Mt. Woolomin and other places already referred to; and the further fact that this mountain is nearly as high as the highest parts of the Barrington Tableland, support the latter view. A final decision must await a more detailed geological survey of the whole region, but as this region is very rugged, heavily timbered and rather inaccessible, many years will probably pass before a detailed geological map will become available.

The southern margin of the Barrington Tableland where it joins the Lower Hunter Tableland is marked by a magnificent scarp trending almost due east and west, and giving a drop of more than 3000 feet from the higher to the lower tableland. This scarp displays all the characteristic features of a true fault scarp, and was diagnosed as such by E. C. Andrews in 1910. In ascending this scarp by the bridle track (the only one available) which follows the divide between the Williams and Paterson Rivers, basalt is first met at an altitude of about 2200 feet, and this rock *appears* to outcrop continuously from there to the summit of the tableland at Carey's Peak (about 5000 feet in altitude), giving an apparent thickness to the volcanic series of about 2800 feet. Detailed mapping might, however, reveal breaks in this apparently continuous outcrop, in which the older rock outcrops are concealed by basalt talus; even without such visible breaks step-faulting could have brought about an apparent increase in the true thickness of the basalt. The topography of this scarp suggests that the Barrington Tableland does not break off to the south in one sheer drop, but that there is a series of steps and treads; there appears to be a well-marked bench some miles in width at an altitude of about 2200 feet, and a second well-marked bench some 2½ miles wide also occurs at an elevation of about 3000 feet. It is interesting to note that the first bench corresponds in height (2200 feet) with the surface of the southern part of the adjoining Upper Hunter Tableland, to be described in the next section, while the second bench, that at 3000 feet, corresponds in height to the base of the basalts along the western side of the Barrington Tableland as already described. These benches have, of course, been very much dissected, and partly removed during the present cycle by the erosive activities of the present-day streams draining the southern margin of the tableland. These streams all flow in a southerly direction, that is directly away from the scarp and not parallel to it.

The features just described suggest the presence of at least two normal faults, one from the 3000-foot to the 2200-foot level, with a throw to the south of 800 feet, and a second from the 2200-foot level to the 1500-foot level of the Lower Hunter Tableland, with a throw of about 700 feet; as has been pointed out previously, basalt occurs also, but to a very limited extent, on the surface of the lower 1500-foot tableland. The geological proof of the existence of these suggested faults will only become possible following a detailed geological mapping of this area, but the evidence now available, both physiographical and geological, very strongly supports E. C. Andrews' view that this great Barrington scarp is a true tectonic scarp; monoclinal folding or sharp warping could also, of course, have produced a somewhat similar feature, but this would not alter the view that this great scarp is primarily a tectonic one and not an erosional one. The western scarp of this tableland will be described in the next section.

C. THE UPPER HUNTER TABLELAND.

Lying immediately to the west of the Barrington Tableland is a lower tableland which is drained for the most part by the Upper Hunter River and its tributaries, and which may therefore be suitably called the Upper Hunter Tableland. In its southern part this tableland has an altitude of 2000 to 2200 feet, as indicated by the height of the trigonometrical stations occurring there, such as Mount Dyrring (2153 feet), Mount Wells (1941 feet), Kangaroo Mountain (2307 feet), Bell Mountain (2240 feet), and Scone Mountain (2200 feet); in addition the main ridges of this area also rise to an approximately similar height. Northwards of Scone Mountain the general altitude increases and reaches some 3000 to 3300 feet, where it joins on to the New England Tableland.

The geological structure of this region is identical with that of the Barrington Tableland as just described, and consists of folded Devonian and Carboniferous strata, upon whose truncated edges lie in places horizontal Tertiary basalts. At Scone Mountain these basalts are less than 200 feet in thickness, but in the northern area they are considerably thicker. It is probable that the Tertiary volcanic series originally covered much of the original surface of this tableland, but the very complete dissection which it has suffered since its uplift has brought about the removal of the volcanic series over most of the area, particularly so in the southern section. The details of the nature of the dissection of this area have already been described in some detail by Browne (1924), and need not therefore be referred to further here.

Along its eastern margin the Upper Hunter Tableland abuts against the great western scarp of the Barrington Tableland, and that this scarp is a fault scarp was first suggested by E. C. Andrews in 1910; there is definite geological and physiographical evidence in support of this view, as may be seen from the section given in Text-figure 1. Along the western margin of the Barrington Tableland, as has already been shown, the base of the Tertiary basalts, together with the peneplained surface of older rocks upon which they rest, stands at a present elevation of about 3000 feet, whereas in the Upper Hunter Tableland immediately to the west the same features stand at an elevation of about 2000–2200 feet, and the drop from the higher to the lower level is a very abrupt one. A normal fault (or faults) with a throw to the west of about 800–1000 feet would explain this feature, as would also a steep monoclinal fold. As the Devonian and Carboniferous strata of this region have not yet been geologically mapped in detail, they afford no present evidence in favour of faulting, but the author has seen evidence of faulting in these older rocks at Stewart's Brook, just where it crosses this suggested line of late Tertiary faulting; the evidence here does not, however, date the faulting, except that it is post-Carboniferous.

The trend of this scarp is approximately meridional and corresponds, but only approximately, to the strike of the strata, and this raises the question as to whether the scarp could be explained as being due to differential erosion; the strata in the two adjoining blocks are, however, of similar age and character, and are equally resistant to erosion; furthermore, the rivers draining this area do not follow either the trend of the scarp or the direction of strike of the strata, their direction of flow ranging from west to south-west, that is, they flow directly away from the scarp, and, as has already been pointed out by Browne (1924), they cut across harder and weaker formations alike; the conditions therefore do not support an origin due to differential erosion, and the whole of the evidence strongly supports the view that this is a tectonic scarp.

The original position of this scarp lies at the western face of Mount Woolomin, where part of it, somewhat modified, of course, still remains, but the scarp as a whole has been much dissected since it was produced, as a result of which it has, both to the north and to the south of Mount Woolomin, retreated some distance to the east of its original position.

Southward, the Upper Hunter Tableland overlaps the Barrington Tableland and here it adjoins the northern portion of the Lower Hunter Tableland, already described; this junction has not been investigated by the writer, but G. D. Osborne (1929) has expressed the view that there is no sharp break between the two, but that the higher region is warped down easterly to the lower.

The Upper Hunter Tableland is also bounded by a fault-scarp along its western side as may be seen from the geological section given in Text-figure 2; it will be obvious from this section that the Mesozoic strata together with the overlying Tertiary basalts of the Goulburn River Tableland must have, at one time, extended eastwards across the present wide valley of Kingdon Ponds Creek to this scarp, and have there come into unconformable contact with the highly-folded Carboniferous strata, and that the junction was a faulted one; further to the north, at Murrurundi, this faulted contact still exists. This line of faulting has been traced by Browne (1924) from Scone to Wingen and called by him the Wingen Fault; he considered it to be of Tertiary age; southward from Scone to Segenhoe where it cuts off the Hunter overthrust of Epi-Permian age, it has been mapped by G. D. Osborne. The Wingen Fault is obviously a normal one with a downthrow to the west and, using the altitude of the base of the basalts as a datum (2000 feet at Scone Mt. in the higher tableland and 1450 feet in the lower tableland), it must have a throw of about 550 feet. From Segenhoe to Wingen this fault has an approximately meridional trend and follows the junction between the Permian and Carboniferous strata, but its position north from Wingen has not yet been definitely determined. North of Wingen the Permian-Carboniferous junction swings to the north-east and, after following this direction for some miles, swings around to almost due west to Murrurundi; here it crosses the Main Divide and north of this point it appears to change its course to a north-north-westerly direction along the western margin of the New England Tableland. Within this big easterly bend from Wingen to Murrurundi the whole of the Permian formations, including the Lower Coal Measures, the Upper Marine Series and the Upper Coal Measures, are strongly folded, and no Mesozoic strata now occur there. Until the district between Wingen and Murrurundi has been surveyed in detail it will not be possible to say whether the Wingen Fault follows this great bend or whether it takes a more direct course through Blandford to Murrurundi. There is some evidence in favour of the latter view because at the junction of the Timor Road with the main road from Wingen to Murrurundi (Portion 60, Parish of Murulla) the dip of the Upper Coal Measures is almost vertical; Mr. C. J. Ivin of Murrurundi

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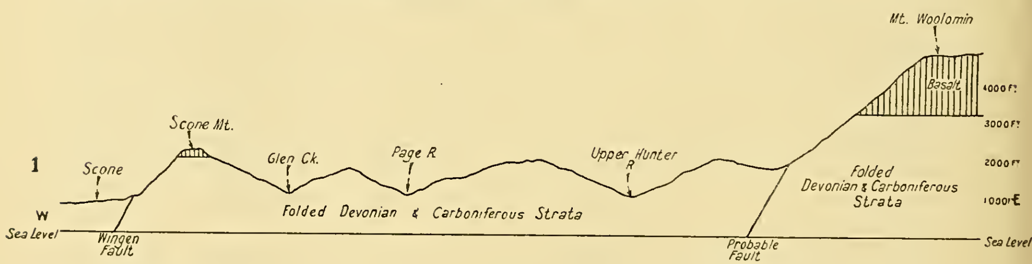

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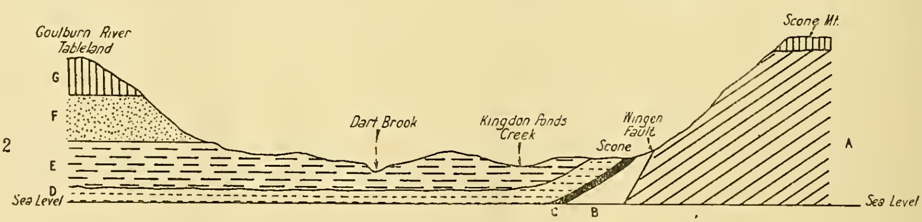

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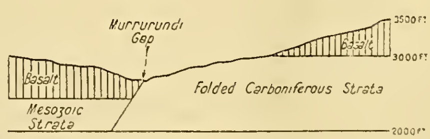

Text-fig. 1.—Diagrammatic Section across Upper Hunter Tableland. Scales: Horizontal, 1 inch = 5 miles; Vertical, 1 inch = 5000 feet.

Text-fig. 2.—Section from Goulburn River Tableland to Scone Mountain. Scales: Horizontal, 1 inch = 2·5 mile; Vertical, 1 inch = 250 feet.

A, Kuttung Series (Carboniferous); B, Lower Marine Series; C, Lower Coal Measures; D, Upper Marine Series; E, Upper Coal Measures; F, Triassic Sandstones and Conglomerates; G, Tertiary Basalt.

Text-fig. 3.—Sketch Section at the Murrurundi Gap. (Not to scale.)

has informed me that similar conditions were also found in a well-hole on Harben Vale Station; both of these localities lie on the line of the general strike of the Wingen Fault. Immediately to the north of these localities the country is fairly flat and covered with soil and alluvium, and consequently the geological structure is obscure. A section across the fault where it crosses the Main Divide at Murrurundi is given in Text-figure 3; here both the Mesozoic strata and the overlying Tertiary volcanic series come into direct contact with the Carboniferous strata along the line of fault, and every one of the formations mentioned shows evidence of the faulting movement; the Carboniferous strata are sheared and strongly jointed adjacent to the fault plane, the Mesozoic strata are strongly tilted and in one place are nearly vertical, whereas a few chains away they are practically horizontal; similarly the Tertiary lava flows close to the fault plane are tilted and dip away from it at an angle of about 25°. Tertiary basalts occur on both sides of the fault, resting upon the folded Carboniferous strata on the upthrow side and on the unfolded Mesozoic strata on the downthrow side, with a difference in the elevation of their base of about 550 feet, giving a similar amount of throw of the fault here to that indicated by the evidence at Scone. The evidence at Murrurundi shows conclusively that the Tertiary basalts have been displaced by the faulting and that the age of the faulting is therefore post-basaltic, that is, late Tertiary. At Murrurundi, and for some miles eastward from there, this fault has a nearly east-west trend; as will be shown in the next section, there is also a probable line of faulting (or monoclinal folding) extending westward from Murrurundi along the northern face of the Liverpool Range; it is possible therefore that these two features are continuous and that the Murrurundi fault has displaced the Wingen fault, and that the fault which extends north-north-west from the northern side of the Murrurundi Gap is a displaced part of the Wingen fault; these possibilities, however, need further investigation.

The southern and south-western margin of the Upper Hunter Tableland from Muswellbrook to Singleton also follows the junction between the Carboniferous and Permian strata which in this region is marked by an overthrust fault (the Hunter Overthrust); H. G. Raggatt (1929) suggested an early Tertiary age for this fault, but later Carey and Osborne (1938) have expressed the opinion that it is of late Permian age. It is improbable that any movement took place on it as late as the close of the Tertiary period, when this tableland was uplifted. The Upper Hunter Tableland is in this region separated from the Lower Hunter Tableland lying to the south of it by the very wide mature valley of the Hunter River, here some 10 to 15 miles in width, so that it is now difficult to determine what the physiographic relationship of these two tablelands was before the valley was eroded, but the fact that the present most northerly projection of the Lower Hunter Tableland in this area (the Broken Back Range) has an altitude of 1925 feet, which closely approaches the height of the southern part of the Upper Hunter Tableland (2200 feet), suggests that the two were originally joined by a warped surface.

D. THE GOULBURN RIVER TABLELAND.

This comprises the whole of the western part of the Hunter River drainage area—an area of about 3000 square miles; along its eastern side it adjoins the Upper Hunter and Lower Hunter Tablelands already described, but it is today actually separated from them by the wide mature valleys of the Hunter River and Kingdon Ponds Creek; on all other sides it extends to the Main Divide. A glance at a map of New South Wales will show that the general meridional trend of the Main Divide of this State is interrupted at the head of the Upper Hunter River by a marked westerly bend; this bend starts at the southern margin of the New England Tableland where, not far from the head of the Upper Hunter River, the Main Divide suddenly turns westward and continues in that direction for some sixty miles, this part of its course being known as the Liverpool Range. The Main Divide then turns southward, maintaining this direction for a distance of sixty miles, and along this section it is so inconspicuous that it has not received any special name; a few miles south of Ulan it again turns suddenly, this time to the south-east, and continues in this direction for about fifty miles, and then resumes its original north-south course. Nearly the whole of the region included in this great westerly bend of the Main Divide is drained by the Goulburn River and its tributaries, and it seems suitable therefore to refer to it as the Goulburn River Tableland.

The Goulburn River traverses this region approximately from west to east and divides it into two unequal parts, a larger northern part which may for convenience be referred to as the Merriwa section, and a smaller southern part which may be referred to as the Bylong section. In both sections the tableland was warped and tilted during uplift, but in opposite directions, the Merriwa section having a gentle but quite definite tilt from north to south, whereas the Bylong section has a much steeper tilt from south to north. There is also in addition a quite definite warping from west to east, which is most marked along the western margin adjacent to the Main Divide. As a result of this warping the altitude of the tableland as a whole varies considerably; it is lowest where the Goulburn River leaves it at its eastern margin, and here the altitude is about 1450 feet; from this point it rises southward to an altitude of 3000 feet, westward to an altitude of 1900 feet and northward to an altitude of about 2200 feet; the highest parts are therefore along its southern, western and northern margins.

The geological structure of the Goulburn River Tableland is similar throughout the whole of its extent, and includes the following formations:

1. The Tertiary Volcanic Series, mainly basalt flows.
2. The Jurassic System—(*a*) sandstones and conglomerates up to 300 feet in thickness; (*b*) the Comiala Shales up to 210 feet in thickness.
3. The Triassic System.
   The Wollar Sandstones up to 650 feet.
4. The Permian System.
   The Upper Coal Measures up to 500 feet in thickness.

The Comiala Shales appear to be limited in their occurrence to the Merriwa section of the tableland.

The above details have been taken from Dulhunty's description (1938) of the geology of the central and northern parts of the region. In addition, the Upper Marine Series have been seen by the writer to outcrop in the lower part of the Bylong valley. A number of geological sections and a geological map of the south-western part of the area have been published by L. J. Jones; his sections show very clearly the marked warping of the tableland in this region. The information published by these observers, together with the author's own observations over very considerable parts of the area, shows that throughout the whole of the Goulburn River Tableland the geological structure is essentially the same.

The volcanic series is quite unfolded and rests unconformably upon the underlying older formations; but its occurrence is limited for the most part to the region lying to the north of the Goulburn River. The Jurassic, Triassic and

Permian formations are apparently quite conformable with one another, and are in general not folded; Dulhunty (1938) has shown, however, that some very gentle folding has taken place in them in the Wollar District; he has shown also that all of these formations had been gently tilted and eroded in pre-basalt times and that the surface upon which the volcanic series rests is a peneplained surface cut in the older rocks; the whole of the formations, as well as the peneplain itself, were subsequently tilted by the warping which accompanied the upward movement (Kosciusko Uplift) which produced the present tablelands. The Mesozoic formations, consisting as they do mainly of sandstones and conglomerates, are very resistant to weathering and erosion, and display steep escarpments where they are exposed in the valley sides; the Upper Coal Measures, on the other hand, consisting mainly of soft shales, are a relatively weak feature and have allowed considerable benching in the central part of the area; over much of the Goulburn River Tableland, however, particularly in the Merriwa section, dissection has not yet exposed the Upper Coal Measures, the surface being still occupied, either by Mesozoic sandstones or by the overlying volcanic series.

Although the Merriwa and Bylong sections of the Goulburn River Tableland have a similar geological structure and similar physiographic histories it will be convenient to describe each separately.

1. *The Merriwa Section.*—As already pointed out, this region lies to the north of the Goulburn River; at its south-eastern margin it has an altitude of from 1400 to 1500 feet, and from here the surface rises northward to the foot of the Liverpool Range, which marks the northern margin, and here the altitude is about 2200 feet. As the volcanic series thickens in a northerly direction the best measure of the amount of tilting of this section of the tableland is given by the underlying sedimentary formations, and for this purpose it will be convenient to take the base of the Mesozoic formations; at Sandy Hollow, at the southern margin, this feature stands at an altitude of 450 feet, whereas at Mount Murulla on the northern margin it stands at an altitude of 1250 feet, a rise of 800 feet in about 36 miles.

Throughout most of the Merriwa section of the tableland the surface is occupied by the volcanic series, but towards its southern margin these thin out and the underlying Mesozoic sandstones are exposed at the surface, particularly so in the bases of the river valleys. An examination of the contact of the volcanic series with the peneplain surface upon which it rests shows that just prior to the outpouring of the basalts, a series of shallow valleys some 300 feet deep had been incised into its surface, and the basalts not only filled many of these valleys but overflowed and spread out over the surface of the peneplain itself. Upon the cessation of the volcanic action, valley development was resumed, with the production of an extensive series of wide mature valleys some 300 feet deep cut alike in the basalts and in the older rocks. These Tertiary valleys (the "upland valleys" of E. C. Andrews) still survive over extensive areas not yet affected by the dissection of the present cycle of erosion. The headwaters of the Goulburn River itself, for example, still lie in one of these Tertiary valleys; at Ulan, where the Goulburn River is flowing northward parallel to and not far east of the Main Divide, it lies in a valley some 3 miles wide, some 300 feet below the tableland surface; its floor is heavily aggraded, and the Mesozoic sandstones which cap the ridges bounding it are covered by a thick mantle of soil; Browne has studied the character of this soil and considers it to be of Tertiary age. The northerly tributaries of the Goulburn River such as Munmurra River and Krui River lie also in similar mature valleys and all of these streams wind sluggishly over their aggraded valley floors, and no downward erosion is at present taking place. In his description of part of this area Dulhunty (1938, p. 308) states that "the peneplain surface has been fairly extensively dissected by the Goulburn River and its tributaries, producing a drainage system which consists mainly of wide shallow valleys exhibiting a considerable degree, and in places an advanced stage, of maturity". These "upland valleys" of the Goulburn River Tableland are quite similar to those which occur in many other parts of New South Wales on similar undissected tableland remnants. The cycle of erosion which produced them was interrupted by the Kosciusko uplift which uplifted the existing tablelands; this uplift rejuvenated the streams and as a result the Goulburn River over much of its course has now cut its channel well below the level of the Tertiary "upland valleys".

Along the northern margin of the Merriwa section stands the Liverpool Range, whose higher peaks range from 3000 to 3500 feet in altitude; this great altitude is due to the great thickness of the volcanic series along this line. The Mesozoic strata continue northward under the volcanic series, and at Warrah Station on the northern side of the range the author found the junction of the two formations to be at an altitude of approximately 1300 feet; at Mount Murulla on the southern side of the Liverpool Range this junction stands at an elevation of approximately 2200 feet, that is, higher by about 900 feet; either faulting or steep warping, or a combination of both, with a downthrow to the north, must have taken place along this east-west line during the Kosciusko uplift; it is obvious therefore that this part of the Main Divide (Liverpool Range) has had a tectonic origin. The great thickness of the basalts (1300 feet or more) along this same line, with their rapid thinning both to the north and to the south, suggests that this was a line of active vulcanism during the Tertiary volcanic epoch, from which basaltic lava flows were poured out, flooding the country northward and southward for many miles.

To the west of the Merriwa section of the Goulburn River Tableland lies the Coolah Tableland which is similar to it both geologically and physiographically; it differs, however, in being notably higher; at Cassilis, which lies just to the east of the Main Divide, the general altitude of the Goulburn River Tableland is 1550 to 1600 feet, whereas immediately to the west of the Main Divide the Coolah Tableland has a general altitude of 1900 to 2000 feet, a difference of 300 to 400 feet; the ascent from the lower to the higher level, which occurs right at the Main Divide, is quite an abrupt one; no evidence of faulting has been found, and the divide here appears therefore to be a monoclinal fold with a throw to the east, possibly with some minor faulting. The Coolah Tableland, like the adjoining part of the Goulburn River Tableland, has a definite southerly warp. Rising above the general level of the Goulburn River Tableland in the south-eastern corner of the Merriwa section is Mount Dangar, which is 2232 feet in altitude; it rises notably above its surroundings on all sides. The author has had no opportunity of ascending this mountain, but it has been described by the late J. E. Carne, who stated that it is capped by a layer of basalt 480 feet in thickness. As the general level of the tableland at its base is not more than 1450 feet, its height above tableland level is about 782 feet; therefore, if J. E. Carne's figures are correct, the lower 302 feet of this mountain must consist of Mesozoic sandstones, and the mountain itself must be a residual of the older tableland out of which the present peneplain was eroded; similar basalt-capped residuals are fairly numerous in the Blue Mountain Tableland immediately to the south.

2. *The Bylong Section.*—This extends southward from the Goulburn River to the Blue Mt. Tableland, a distance varying from about 16 miles on its western margin to about 24 miles on its eastern margin. To the west it adjoins the Mudgee-Gulgong Tableland, and from there extends eastward to Baerami Creek, a distance of about 48 miles. Its surface has a very marked tilt from south to north. The altitude along its northern margin is about 1450 feet (but rising somewhat westward), and it rises rapidly southward, reaching an altitude of 3000 feet where it joins the Blue Mountain Tableland. Its geological structure is similar to that of the Merriwa section, excepting that the Tertiary basalts are practically absent, the surface of the tableland consisting of massive Mesozoic sandstones.

Owing to the initial steeper slope of the surface of this section of the Hunter River Tableland, as compared with the Merriwa section, the streams have a much steeper grade, as a consequence of which dissection during the present cycle has proceeded much further; the steeper dip of the underlying strata has brought the weak Upper Coal Measures well above the temporary base-level (the Goulburn River channel) with the result that, as soon as these streams had cut their channels through the Mesozoic sandstone, rapid widening of the valleys took place, with the production of wide flat-floored valleys which pass upward into narrow gorges as the divide is approached.

This Pleistocene dissection of the tableland has almost completely removed the original Tertiary topography except for small areas along the western margin close to the Main Divide where some of the original peneplain surface with its upland valleys still survives. The Permian-Mesozoic formations along the western margin end at the Main Divide, and immediately to the west and at a similar altitude an exactly similar topography of peneplain and upland valleys exists on the Mudgee–Gulgong Tableland, where the underlying formations are entirely different, consisting of highly-folded Lower Palaeozoic strata with extensive granite intrusions. The Main Divide here is so inconspicuous that in travelling from Ulan westward to Mudgee it is difficult to realize just where the divide is and the monoclinal fold previously described as occurring further to the north along the Main Divide between Cassilis and Coolah has here become a mere warping of the tableland toward the east.

The southern margin of the Bylong Section where it adjoins the Blue Mountain Tableland is marked by a line of sharp warping or faulting, or a combination of both. At Solomon's Gap on the Rylstone–Bylong Road, on the Blue Mountain Tableland, the base of the Triassic sandstones is at an altitude of about 2300 feet, whereas at The Gulf some few miles to the north, the base of the same formation is at an altitude of 1700 feet, and at this point both the Triassic sandstones and the underlying coal measures show evidence of faulting; a throw of about 600 feet to the north is indicated. This line of faulting and warping has an approximate east-west trend and extends westward into the Mudgee District where folded Lower Palaeozoic strata have been similarly affected.

Some of the southern tributaries of the Goulburn River, notably Widdin Brook and Baerami Creek, have cut their channels southward beyond this tectonic line during the present cycle of erosion, and there has been a southerly migration of the divide there for a distance of 12 miles or more; this migration is still going on.

Taking the Goulburn River Tableland as a whole it will be seen from the description already given that its northern, western and southern boundaries are primarily of tectonic origin, and that migration of the divide as a result of headward erosion of the streams during the existing cycle of erosion has only occurred to a very limited extent in the south-eastern corner. It is quite obvious, therefore, that the great western bend of the Main Divide here is not due, as suggested by Taylor (1906), to the erosional activities of the present-day streams in the weak Upper Coal Measures, but has resulted from differential earth movements; as already pointed out, the weak Upper Coal Measures are only exposed at the surface in this region to a very limited extent.

Along the eastern side of the Goulburn River Tableland the Hunter River and its tributary, Kingdon Ponds Creek, have developed a very wide mature valley which now completely separates this tableland from the Upper Hunter and Lower Hunter Tablelands. This valley, although running at right angles to it, is continuous with the valley of the Lower Hunter already described and has been developed under similar geological conditions; in its details it is similar in every way.

E. THE BLUE MOUNTAIN TABLELAND.

Very little of this tableland falls within the drainage area of the Hunter River, consequently only a very limited description is necessary here, a fuller description being retained for a later paper. Its altitude where it adjoins the southern margin of the Goulburn River Tableland is from 3000 to 3500 feet; eastward where it adjoins the Lower Hunter Tableland the general altitude is about 2000 feet. Its geological structure here is quite similar to that of the Goulburn River Tableland.

THE HUNTER RIVER AND ITS VALLEY.

The Hunter River proper is formed by the junction of two important streams, the Upper Hunter River and the Goulburn River; these unite near the village of Denman and the combined streams, conveniently referred to as the Lower Hunter, flow thence in a general easterly direction to the coast.

The Upper Hunter River and its tributaries drain nearly the whole of the Upper Hunter Tableland, the western margin of the Barrington Tableland, and the eastern margin of the Merriwa section of the Goulburn River Tableland. The Upper Hunter River itself rises in the southern margin of the New England Tableland and flows in a general south-south-west direction obliquely across the outcropping edges of folded Devonian and Carboniferous strata in a relatively narrow valley with only limited flood plains here and there; at Segenhoe, where it crosses a belt of resistant Kuttung strata in a wide gap, it flows out into the very wide mature valley already described as lying between the Goulburn River and Upper Hunter Tablelands. Its left bank tributaries such as Moonan Brook, Stewart's Brook and Rouchel Brook all rise in the western margin of the Barrington Tableland and flow almost due west across the strike of the strata to join the parent stream. One of its right bank tributaries, the Page River, has a somewhat anomalous course; this stream rises in the Liverpool Ranges immediately to the west of Murrurundi, and for some miles easterly it flows first in Mesozoic strata and then in Permian strata following the general direction of the Murrurundi fault in a wide mature valley. The weak Permian strata extend from here southward to the valley of Kingdon Ponds Creek, and this would appear to be the natural direction for this drainage system to have taken; instead, it continues south-easterly, leaves the weak Permian formation, and crosses a belt of very resistant folded Middle Carboniferous strata (Kuttung Series) in a typical gorge; at the eastern end of this gorge it enters a relatively weak belt of Lower Carboniferous strata (the Burindi Series), turns south and follows the strike of these beds in a moderately mature valley to its junction with the Upper Hunter at Segenhoe. At Scone there is a remarkable wind gap in the belt of resistant Kuttung Series only a short distance to the west of the south-flowing Page River; the base of this gap is less than 100 feet above the river level, and contains coarse river gravels, and it appears probable that the Page River at one time flowed through this gap to join Kingdon Ponds Creek, which flows on the other side of the gap.

The only other important tributary of the Upper Hunter River on its right bank is Kingdon Ponds Creek; this stream rises on the south side of the Liverpool Range and flows from there almost due south, parallel to the Wingen Fault Scarp, to its junction with the parent stream near Aberdeen; its channel traverses the weak Upper Coal Measures in which it has developed the very wide mature valley already described as lying between the Upper Hunter and Goulburn River Tablelands; this north-south valley of Kingdon Ponds Creek joins and is continuous with the east-west valley of the Lower Hunter River.

From the description given of the Upper Hunter River and its tributaries it seems obvious that the courses of these streams had already been determined before the uplift which produced the existing tableland and that they are revived streams; Kingdon Ponds Creek may be an exception, as its course may have been determined by the Wingen Fault Scarp, subsequent to the formation of the latter.

The Goulburn River rises in the Main Divide on the far western margin of the Hunter River drainage area; from its source near Ulan it flows almost due north, parallel and close to the Main Divide for a distance of about 12 miles; it then turns east and, except for the big northerly bend near Wollar, it maintains a general easterly direction to its junction with the Upper Hunter at Denman. The origin of the northerly bend near Wollar has not been investigated by the writer, but has been discussed by Dulhunty (1938). The Goulburn River from its source to nearly as far downstream as Crowie still flows along the floor of its old Tertiary valley some 300 feet below the tableland level, as do also some of its tributaries such as Krui River and Munmurra River, but downstream from Crowie it has deepened its channel below the Tertiary "upland valley" level; for example, at its junction with Munmurra River its channel is now 550 feet below the tableland level; that is 250 feet below the "upland valley" level; still further downstream at its junction with Bylong Creek its channel is at least 600 feet below the tableland level; the figures for these two localities have been taken from Dulhunty's map. At Sandy Hollow, still farther downstream, the river bed is at a present elevation of 450 feet and is therefore about 1000 feet below the tableland level. J. A. Dulhunty's statement of "a uniform depth of the Goulburn Valley below the peneplain level which varies from 300 to 400 feet throughout the entire course of the river" is therefore not correct and is actually in conflict with the figures given on his own map.

The marked warping which accompanied the uplift of the Goulburn River Tableland as already described has brought the resistant series of Mesozoic sandstones to their lowest level in this district just where the Goulburn River crosses them above Sandy Hollow, and here their base stands at an elevation of about 450 feet; these conditions have retarded the downward cutting by the Goulburn River during the present cycle of erosion, and have correspondingly retarded the dissection of the whole of the Goulburn River Tableland above this point, with the result that the tablelands in this region are as a whole less dissected than any other part of the Hunter River drainage area. At Sandy Hollow the river has now cut through the resistant sandstone into the underlying weak coal measures and has developed a wide mature valley which eastwards merges into the wide mature valley of the Hunter River. Upstream from Sandy Hollow, however, the river channel is still confined to a rugged gorge cut in the sandstones; similar conditions occur along the lower courses of the tributary streams in this region, such for example as Merriwa Creek. Still further upstream the base of the Mesozoic sandstones, owing to their fairly steep easterly dip, is at a much higher elevation than at Sandy Hollow, and here the Upper Coal Measures are exposed in the stream channels and valley widening is much in evidence.

On its northern side the Goulburn River receives a number of tributaries which rise on the southern side of the Liverpool Ranges and flow almost due south to meet the parent stream; Tertiary basalt flows cap most of this region, and as these thicken northwards and attain a great thickness in the Liverpool Ranges, it would seem probable that these southerly courses are consequent on the slope of the surface of the basalts and had already been determined before the tableland was uplifted. On its southern side the Goulburn River receives a number of tributaries which rise in the Blue Mountain Tableland and flow more or less due north to join the parent stream; there are practically no Tertiary lava flows in this region and their direction of flow would appear at first sight to have been determined by the northerly slope of the tableland here; but the north-south trend of such of the Tertiary "upland valleys" which survive in this area indicates that this trend may have already been determined prior to the Kosciusko Uplift. Some of these southern tributaries such as Widdin Brook, have carried their channels some miles to the south of the line of warping and faulting which marks the northern margin of the Blue Mountain Tableland, and have thus brought about a southerly migration of the Main Divide during the present cycle of erosion; this migration is still going on. The evidence in this region therefore suggests that for many of the streams draining the Goulburn River Tableland the direction of flow had already been determined in pre-Kosciusko times and that they are therefore revived streams; the position of the eastern part of the course of the Goulburn River in the "hinge" when the northerly tilt of the Bylong section of the tableland meets the southerly tilt of the Merriwa section suggests the possibility that this part of its course may have been determined by the warping which accompanied the Kosciusko Uplift.

The Hunter River (Lower Hunter), after its junction with the Goulburn River, turns eastward and follows this general direction to the coast in the wide mature valley already described. It receives a number of important tributaries on its left bank, the two most important of which are the Paterson River and the Williams River; these streams rise on the southern margin of the Barrington Tableland and flow in a general south-south-east direction, this direction of flow conforming more or less to the strike of folded Carboniferous strata of this region. The region drained by these two streams receives a more abundant and more regular rainfall than any other part of the drainage area of the Hunter River, and it will play an important part in the future water conservation of this region. Of the tributaries received by the Lower Hunter on its right bank the only one of special interest is the Wollombi Brook; this stream rises in the coast range and for the first few miles of its course flows in a general westerly direction to Wollombi, and from here it turns and flows in a general north-north-west direction to its junction with the Hunter River above Singleton. This direction of flow as compared with the easterly direction of flow of the parent stream constitutes what Taylor has called a "boat-hook" junction; the Upper Hunter also makes a similar "boat-hook" junction at Denman, and on this evidence Taylor (1911) suggested that all of that part of the Hunter River System lying to the west of Singleton at one time flowed westward to join the Macquarie River, the adjoining stream on the western side of the present Main Divide; the author, however, does not find any evidence in support of this view. The anomalous course of Wollombi Brook can be best explained as being due to the upwarping of the relatively high tableland block, known as the Broken Back Range, during the Kosciusko Uplift. This relatively high block lies immediately to the north of the western-flowing part of the Wollombi Brook, and its uplift must have blocked drainage towards the north; it has a definite south-westerly tilt on its south-western side and these features caused the drainage to be diverted first to the west and finally to the north-north-west. The south-westerly direction of flow of the Upper Hunter River can be explained as being due to the piling up of the great thickness (nearly 2000 feet) of basaltic lava flows on the eastern (seaward) side of the watershed of that stream during the Upper Tertiary Period, and the subsequent uplift of the Barrington Tableland to a higher level than the Upper Hunter Tableland has again in the present cycle blocked drainage to the east and south-east.

THE RIVER TERRACES.

Within the valley of the Hunter River, but particularly along the wide mature valleys of the Kingdon Ponds Creek and the Lower Hunter, there are, as was pointed out by the writer in 1923, several well-marked terraces or benches as follows:

(*a*) The Charleston Bench, 400 to 450 feet above present river level;
(*b*) The East Maitland Bench, 125 to 130 feet above present river level;
(*c*) The Raymond Terrace Bench, 15 to 20 feet above present river level.

(*a*) *The Charleston Bench* is particularly well developed in the coastal area immediately to the south and south-west of the town of Newcastle where it has a present elevation of 400 to 450 feet above sea-level; it also extends southward beyond the Hunter River watershed to at least as far south as Gosford. The village of Charleston lies on the surface of this bench and therefore affords a suitable name for it. This same bench is found to occur as far up the Hunter Valley as the town of Muswellbrook, where it is well developed to the south and east of that town, and has a present elevation there of about 900 feet, that is, about 430 feet above the level of the channel of the Hunter River at that locality. In this district it has been developed in strongly folded Permian strata and consequently is not due to local benching in weak horizontal strata, but has been produced by river erosion when the river flowed at the same level as the bench. This bench has been much dissected since it was uplifted to its present position, and has been largely removed.

(*b*) *The East Maitland Bench.*—This erosion level is very widely developed along the valley of the Hunter River from the coast to Muswellbrook and thence northward along the valley of Kingdon Ponds Creek to Wingen; as it is particularly well developed about the town of East Maitland, this affords a suitable name for it. It has a general elevation of about 125 feet above present river-level and is a definite rock bench cut alike in nearly horizontal strata and in folded strata, and is covered in places with a thin layer of river sands and gravels. In many places it extends almost to the foot of the existing valley sides, showing that there has been only limited valley widening since it was formed; since its uplift it has suffered considerable dissection, with the development of fairly extensive flood plains below it at present river levels, but the fact that it still survives over very extensive areas, in many of which the strata out of which it has been cut consist of very weak shales, indicates that it is geologically young.

(*c*) *The Raymond Terrace Bench.*—This is an alluvial bench some 15 to 20 feet above sea-level and limited in its occurrence to the lower part of the Hunter River Valley, extending from West Maitland to the coast; at Largs near West Maitland a raised beach containing marine shells is associated with this bench; these features have been described by David (1907).

The Faulting and Warping.

Evidence for the existence of a number of tectonic scarps in this region has been given. Some of these scarps are probably fault scarps; some are due to monoclinal folding and some possibly to a combination of warping and faulting. These faults and folds fall into two definite groups, (*a*) those having a meridional or approximately north-south trend, that is, parallel to the north-south axes of uplift of the main tableland belt, and (*b*) those striking east-west, that is, transverse to (*a*); the more important of these are as follows:

(*a*) *Meridional faults and monoclines.*

1. The Woolomin Fault—western margin of Barrington Tableland.
2. The Wingen Fault—western margin of Upper Hunter Tableland.
3. The Cassilis Monocline—western margin of Goulburn River Tableland.

(*b*) *Transverse Faults and Monoclines.*

1. The Barrington Faults—southern margin of Barrington Tableland.
2. The Murrurundi Faults—southern margin of New England Tableland.
3. The Liverpool Range Fault (? monocline)—northern margin of Liverpool Ranges.
4. The Gulf Fault or Monocline—southern margin of Goulburn River Tableland.

As some of these have definitely faulted and displaced the Tertiary basalts they are obviously post-basaltic in age and all of them are considered to have been produced during the differential uplift which originated the existing tablelands (Kosciusko Uplift).

It is interesting to note that the Tertiary basalts attain their greatest thickness along some of these tectonic lines; adjacent to the Barrington-Woolomin faults, for example, these basalts range up to 2000 feet in thickness, and along the line of the Liverpool Range Fault (or monocline) they range up to 1500 feet in thickness; elsewhere they are much thinner. Also associated with the Gulf line of faulting or folding occur the large alkaline intrusions referred to by the writer (1932) in a previous paper; such lines therefore appear to have already been lines of weakness in the earth's crust before the present tablelands were uplifted.

It has already been pointed out that the relatively low tableland area drained by the Hunter River lies between two relatively higher tableland blocks, the Northern or New England Tableland on its northern side, and the Central Tableland on its southern side, and it is interesting to note that here the Central Tableland is definitely "stepped back" westward in relation to the Northern Tableland. Each of these two extensive tableland regions is divisible broadly into three belts parallel to one another, and with an approximately north-south trend, that is, parallel to the Main Divide and to the coast; in each case there is a relatively high central belt, which we may call belt B, 3000 feet and upward in altitude, flanked to the east and west by relatively lower belts, which we may call A and C respectively, whose general altitude varies from 1000 to 2000 feet (even less in places). The coastal belt A of the Northern Tableland ends abruptly at its southern end at the ocean; reference to the map (Plate x) shows a marked westerly bend of the coast here, known as the Newcastle Bight, while belts B and C of the Northern Tableland at their southern end come opposite to belts A and B of the Central Tableland. This stepping back of the Central Tableland appears to be definitely associated with the transverse faults and flexures of the Hunter River area, and still further supports the view that the Cassilis geocol, as Taylor called this region, is a tectonic feature and not an erosional feature.

Summary and Conclusions.

In the descriptions already given it has been shown that the region drained by the Hunter River system was at one time a peneplain developed in strata ranging from Devonian to Jurassic in age; following a slight uplift of this peneplain, valleys were developed some 300 feet in depth. This valley development was interrupted by pronounced vulcanism, during which extensive lava flows were poured out over much of the area; these not only filled some of the valleys but poured over, in many places, the surface of the peneplain itself. Subsequent to the vulcanism, valley development continued until there had been produced an extensive series of very wide mature valleys, referred to in this paper as the "upland valleys". The whole region with its lava flows and upland valleys was then uplifted to form the existing tablelands ranging from 1400 to 5000 feet in altitude; this differential uplift was accompanied by extensive warping, monoclinal folding, and faulting. This has been followed by a compound cycle of erosion, which is still in progress, and the pre-existing streams, revived by the uplift, have dissected the tablelands to the early mature stage of development. In limited parts of the area, particularly in the far western portion about the headwaters of the Goulburn River, some of the uplifted Tertiary topography still survives and here the present-day streams may be seen heading back into the Tertiary "upland valleys".

These features are not peculiar to this region, but extend over the whole of the eastern part of the State, and their age and origin have already been discussed by the writer in a previous paper (1937); the events and the geological ages assigned to them were as follows:

1. Eocene to Miocene—a cycle of erosion during which the peneplain (Great East Australian Peneplain) was produced.
2. Epi-Miocene—an epeirogenic uplift which produced a series of low tablelands some 300 to 400 feet in altitude.
3. Lower Pliocene—erosion of valleys which in other parts of the State contain fossil leaves and fruits.
4. Lower Pliocene—widespread volcanic activity with the pouring out of floods of basaltic lavas.
5. Upper Pliocene—continuation of valley formation with the development of the "upland valleys".
6. Late Pliocene—the Kosciusko Uplift which produced the existing tablelands.
7. Pleistocene to Recent.—The existing cycle of erosion during which the tablelands have been dissected to their present condition. The erosion benches at 400 and 130 feet above present river level indicate pauses in the general uplift.

The evidence for the area now described fully confirms the above succession of events; under this scheme the Hunter River valley proper is post-Tertiary in age.

More recently H. G. Raggatt (1938) has suggested a Tertiary age for the Hunter River Valley, and it becomes necessary to examine the evidence put forward by him in support of this view. He has described the occurrence, at various places in the Hunter Valley lying between Singleton and Denman, of a layer of silicified sands and gravels ("grey-billy") lying upon an erosion surface some 130 feet above present river level, and he considers that the only way in which these deposits could have become silicified was by the pouring over them of basaltic lava flows; he admits, however, that no basalts occur on this level today. These supposed basalt flows are considered by him to have been of Tertiary age, and that therefore the Hunter Valley itself must be of Tertiary age.

The erosion level referred to is, of course, the one described in this paper as the East Maitland Bench; this bench is developed in many places in very weak strata; at East Maitland the strata are gently folded coal-measures consisting of interbedded shales and sandstones; at Denman and northward from there the strata are nearly horizontal shales, a very weak structure. Following an uplift of this bench (or possibly a corresponding lowering of sea-level) the Hunter River has today cut its channel down to present base-level, and has produced at this lower level a flood-plain of only moderate width and extent as compared with the original area of the bench itself, while the surviving parts of the latter have suffered only moderate dissection. These features all suggest that this bench is geologically young; had it originated back in the Tertiary Period it would surely have been largely removed by now, and had it ever been covered by basalt flows it is difficult to imagine how these could have been completely stripped off and the underlying weak shales left behind.

It is quite true of course that "grey-billy" occurs under basalt flows in many parts of New South Wales, but similar rocks also occupy extensive areas of the surface in the western part of the State where no basalts occur; these are considered to have been silicified by underground water ascending under the influence of capillarity under the conditions of the dry climate which exists there. The climate of that part of the Hunter Valley referred to by Raggatt is not so dry as the western part of the State; nevertheless it has a relatively dry climate as compared with most localities in Eastern New South Wales. On the map (Plate x) there is a heavy black line which indicates the approximate position of the 25-inch isohyet, and it will be noticed that it makes a marked bend to the east in the Hunter Valley extending almost to Singleton. At Denman the average rainfall over a long period of years is only about 22 inches, but this does not give a true picture because in some years the rainfall has fallen as low as 11 inches; such drought conditions may continue for several successive years, and in such dry years the rain that does fall is largely confined to a short part of the year with long intervening rainless periods. There is evidence from other parts of the world of epochs of much drier conditions during the Pleistocene Period than those which exist at present, and it is quite possible that such epochs of drier climate affected this part of the world also; one might even quote the deposits of "grey-billy" as evidence in favour of this view. Quite apart from these suppositions, however, there is the important fact that silicification of gravels is actually taking place in Eastern Australia today under the present climatic conditions. Dr. E. O. Marks has informed the writer that it is taking place in many places in Eastern Queensland, while the writer has recently observed in the Portland District of New South Wales deposits of silicified gravels in quite youthful gullies on the steep hillsides of that region. It appears to the writer therefore that the silicified gravels described by Raggatt are not necessarily proof of the former existence of basalt flows immediately above them. Even if his conclusion is the correct one, it does not follow that such basalt flows are of Tertiary age as he suggests; in support of his view he quotes a statement by Dulhunty (1938) that Tertiary Basalts have flowed into the Goulburn Valley. Of the three localities mentioned by this writer one occurs in the Goulburn Valley at Crowie and a second in the valley of Wollar Creek near Wollar, and in both of these cases the details given of the altitude at which they occur show that the basalts flowed into the pre-Kosciusko "upland valleys" and not into the post-Kosciusko valleys of these streams. The third occurrence mentioned by Dulhunty is in the Bylong Valley near the junction of this stream with the Goulburn River; this occurrence has been visited by the writer and in his opinion it is not part of a lava flow, but is a large volcanic neck; in all of its features it closely resembles the undoubted basaltic volcanic neck which occurs near the head of the Bylong Valley at a place called The Gulf, and which was described by J. E. Carne (1903); a similar large volcanic neck also occurs a short distance east of the Main Divide on the Mudgee-Wollar Road. In many places in the region now being described Tertiary basalt flows cap the tablelands right on the edge of the present-day valley walls, upwards of 1000 feet in thickness in some localities, but in no cases known to the writer have such basalts flowed into the present-day valleys of the Hunter River or its tributaries. If the basalt flows postulated by Raggatt ever did exist, they would undoubtedly have been of Pleistocene and not of Tertiary age.

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EXPLANATION OF PLATE X.

Map of the Hunter River Watershed.